

USSN 09/803,044

Art Unit 1641

#### Remarks

The applicants have restricted this application to alkene reactants without prejudice to their right to file divisional applications to the inventions defined in the other groups defined by the Examiner. This amendment also overcomes the majority of the Examiner's objections under 35 U.S.C 112, which relate to reactants other than alkenes. In addition, the applicants have specified that the thermal process takes place at a moderately elevated temperature less than 250°C consistent with the teachings of the specification.

The applicants have also specified that the protective layer is a passivating layer (see for example, line 16, page 12). The purpose of the protective layer is not primarily to permit reaction with further reactants, but rather to passivate the surface of the porous silicon so as to prevent degradation of its inherent properties over time due to reaction with active species.

The applicants have also specified that the alkenes are deoxygenated. The alkenes have to penetrate into the microscopic pores and passivate the porous silicon as will be explained in more detail below. In order to achieve this result, it is important that the alkenes be both deoxygenated and purified in the manner claimed.

The remaining formal objections have been attended to. Claims 34 and 35 have been redrafted in Jepson format and directed to detection devices including a stabilized porous silicon structure made by the processes defined respectively in claims 1 and 21. It is believed that these claims are allowable as dependent claims in their amended form.

The invention addresses the problem of stabilizing porous silicon. As discussed in the specification, porous silicon typically has a surface terminated with hydrogen atoms. While these initially provide good electronic quality films, the hydrogen monolayer does not protect against photoluminescence quenching from chemical absorbates over a period of time.

A particular problem arises in the passivation of porous silicon due to the presence of the nanopores that characterize porous silicon. Many attempts have been made to stabilize or passivate porous silicon, but they have all suffered from certain disadvantages. For example, oxygen stabilization affects the photoluminescence intensity, metals provide good coverage and organic molecules still permit eventual oxidation. The challenge was

USSN 09/803,044

Art Unit 1641

to provide a way of stabilizing porous silicon that did not suffer from these disadvantages. The applicants have found surprisingly that samples treated with purified alkenes, and in particular 1-decene, show surprising robustness as determined by subjecting the samples to a number of treatments including sonication, boiling in  $\text{CHCl}_3$ , immersion in MilliQ water, immersion in 1.2N HCl, and immersion in aqueous HF solution (see paragraph commencing at line 16, page 12). These results are not predictable from the prior art.

The Examiner has cited Sieval under 35 USC 102 (b) as allegedly anticipating claims 1-7, 15-18, 21, 23, 25, 28-35. This rejection is respectfully traversed. Claims 1 and 21 are clearly limited to a process involving processing a porous silicon substrate. Contrary to the Examiner's assertion Sieval does not relate to porous silicon (and it is not understood on what basis the Examiner makes this assertion), but instead relates to crystalline silicon. There is no mention in Sieval to porous silicon, and indeed it is clear from the discussion that the article relates to ordinary crystalline silicon. Figure 1 shows a planar surface and suggests bulk silicon is being discussed. The term "Porous silicon" is very well recognized in the art and has a special meaning. A quick search on the USPTO database discloses a number of patents relating to "porous silicon". For example, in US patent no. 5,510,663, porous silicon is described as "a spongy phase of Si". Porous silicon has special properties not possessed by ordinary crystalline silicon, notably photoluminescence. Also, a reference to porous silicon can be found, for example at <http://www.bath.ac.uk/physics/groups/opto/psilicon.html>. This reference contains the following exemplary explanation of one way of making porous silicon: "Porous silicon is made by dissolving a bulk silicon wafer in an electrochemical cell containing hydrogen fluoride solution. The remaining porous layer is a complicated network of silicon wires each with a thickness of between 2-5 nm (20,000 times thinner than a human hair). The porosity of a sample is defined as the amount of air in the material after processing has finished, so a 45% porous sample would contain 45% air and 55% silicon. A typical sample could have an internal surface area of up to several hundred square metres per cubic centimetre." The Examiner will appreciate that such a material, especially with its microscopic nanopores, will be expected to have properties very different from ordinary crystalline silicon.

In accordance with precedent,

USSN 09/803,044

Art Unit 1641

"A claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently, described in a single prior art reference."

*Verdegaard Bros. v. Union Oil Co. of California*, 2 USPQ2d 1051.

There is no basis for suggesting that the silicon in Sieval is inherently porous silicon; on the contrary the normal state of silicon would be crystalline silicon. Special processing is required to create porous silicon (see above reference). Consequently, in the absence of specific teaching, this feature cannot be taken as inherent. Sieval does not therefore anticipate claims 1 and 21.

Sieval teaches the use of 1-alkenes for the purpose of forming a functionalized monolayer on a hydrogen-terminated crystalline silicon surface. The monolayer is intended to react further with other reactants. The object of the present invention is to provide a protective layer whose purpose is to ensure that degradation of the inherent properties of porous silicon does not occur. There is no reason to suppose from a reading of Sieval that alkenes would be effective in passivating porous silicon.

Porous silicon consists of a nanostructure of microscopic pores leading to a large surface area. Si(100) has a bandgap of 1.15 eV, while porous silicon has a bandgap that opens up as a function of its porosity. The different band gaps implies different reaction mechanisms and pathways, and it is by no means apparent to one skilled in the art that a mechanism applicable to crystalline silicon would be applicable to porous silicon. On the contrary, the nanostructure nature of porous silicon has made it a very difficult material to stabilize. The properties of porous silicon are quite different from bulk (crystalline) silicon. Techniques that work on crystalline silicon typically do not work on porous silicon. For instance, one would expect a difference between bulk properties (in the case of crystalline material) and nanocrystallites (in the case of porous silicon). The major difference between bulk material and nanoparticles is not only related to steric effect (bulk) but also to the electronic properties of both materials. There is a review paper on this aspect: Size-dependent chemistry: properties of nanocrystals C.N.R. Rao, G.U. Kulkarni, P.J. Thomas, and P.P. Edwards, Chem; Eur. J; 2002, 8, N°1, pp29. This paper discusses the difference in properties of bulk materials and nanocrystals, such as are found in porous silicon, and reveals that they are quite different.

USSN 09/803,044

Art Unit 1641

Porous silicon is not the same as bulk or crystalline silicon because of the presence of the nanopores. Materials that will adhere to the surface typically will not penetrate the nanopores. The reason that alkenes are so effective is that they unexpectedly penetrate into the pores. There is absolutely no teaching in the art of the utility of alkenes in the context of porous silicon, and in particular there is no teaching in the prior art literature of their ability to penetrate the pores of porous silicon and thereby provide the coverage needed for efficient passivation. Indeed, when the inventors discovered this property of alkenes, they found it a very surprising result.

The applicants have experimentally demonstrated (see page 13, line 8 et seq.) the surprising result that alkene reactants, when used in the manner defined in the claims, contrary to expectations result in stable passivation layers on porous silicon. The applicants have demonstrated that the thermal process is very efficient. The hydrosilylation reaction occurs throughout the internal surfaces of the porous layer. The Auger depth profiles results referred to in the paragraph commencing at line 4, page 12 confirm this result. The alkenes surprisingly result in more than just the modification of the upper surface of the substrate.

The cited Sieval reference deals with the formation of functionalized monolayers on crystalline silicon. It teaches nothing about the passivation of porous silicon. There is no reason why one skilled in the art would consider Sieval relevant in addressing the problem at hand, namely the passivation of porous silicon. Sieval should therefore not be considered analogous art. In discussing the question of analogous art, the Federal Circuit, considering the need for a reference to be "reasonably pertinent" has stated in *In re Wood*, 202 USPQ 171, that:

[a] reference is reasonably pertinent if...it is one which, because of the matter with which it deals, logically would have commended itself to the inventor's attention in considering his problem...If a reference disclosure has the same purpose as the claimed invention, the reference relates to the same problem...[I]f it is directed to a different purpose, the inventor would accordingly have had less motivation or occasion to consider it.

Since Sieval deals with a material having a different structure with difference chemical and physical properties, and furthermore does not address the question of providing a

USSN 09/803,044

Art Unit 1641

protective layer, but on the contrary teaches the formation of a functionalized monolayer intended for further reaction, the applicants respectfully submit that there is no reason for one skilled in the art to suppose that the teachings of Sieval would be of assistance in solving the problem with which the present invention is concerned, and which relates specifically to the passivation of porous silicon.

It is thus quite clear that Sieval does not teach a solution to the problem of how to passivate porous silicon in a stable manner. It cannot be considered obvious in the light of Sieval that a stable monolayer would form on porous silicon, which has completely different properties from bulk silicon. Indeed, the inventors themselves were surprised at the results achieved because of the difficulty that had been experienced by persons skilled in the art in passivating the nanostructure formed by the pores in porous silicon. Even if it were considered obvious to try the solution of Sieval among the many possible alternatives, which is not admitted, the Federal Circuit has made it clear the "obvious to try" is not the appropriate standard for obviousness. In *In re Lindell*, 155 USPQ 521, the CCPA stated:

[W]e have criticized the "obvious to try" test on several recent occasions...

[A]pplication of the "obvious to try" test would often deny patent protection to inventions growing out of well-planned research which is, of course, guided into those areas in which success is deemed most likely. These are, perhaps, the obvious areas to try. But resulting inventions are not necessarily obvious. Serendipity is not a prerequisite to patentability. Our view is that the "obvious-to-try" test is not a sufficiently discriminatory test."

Thus, even if it were obvious to try the technique described in the Sieval paper on porous silicon, which is not conceded, that would not be a sufficient test to establish *prima facie* obviousness under 35 USC 103(a).

The provisional double patenting rejection with respect to the copending application is respectfully traversed for similar reasons to those discussed above. The copending application relates to the functionalization of crystalline silicon, or the preparation of crystalline silicon so an attached linker molecule can react with a bio-molecule to form an attached linker molecule having an activated functionality. The present application is concerned primarily with the passivation of porous silicon. Functionalization involves adding functional groups to promote further reaction. Passivation involves the stabilization of the surface to prevent degradation of the properties with time.

USSN 09/803,044

Art Unit 1641

Additionally, the copending application relates to crystalline or bulk silicon, not porous silicon. The properties of the latter are quite different due to the multiplicity of nanopores formed in the silicon surface. Effective passivation requires the passivating agent to penetrate into, or wet, the pores so as to cover the silicon within the pores. Agents that are useful on the surface of crystalline, typically, will not work for porous silicon, where the reactive environment is completely different. The invention is based in part on the surprising results that alkenes work well as passivators for porous silicon, and this has been found due to the fact that alkenes unexpectedly penetrate into, or in other words wet, the microscope pores (nanometers in size) and completely cover the surface including the surface portions extending into the pores. In order to provide adequate passivation of porous silicon, the passivator has to be capable of penetrating the pores so as to cover the surface within the pore. This is usually the fundamental problem in finding a suitable material. The fact that alkenes have utility for this purpose is not obvious from the invention claimed in the copending application.

It is therefore respectfully submitted that the independent claims are patentably distinct from the claims of the copending application because they relate to a entirely different material (porous silicon) which is associated with an entirely different set of properties. It would not be obvious in the light of the invention claimed in the copending application, that alkenes would serve as effective passivators for porous silicon.

Reconsideration and allowance are therefore respectfully requested.

Respectfully submitted

Marks & Clerk  
P.O.Box 957, Station B  
Ottawa, Ontario  
Canada K1P 5S7  
(613) 236-9561

BY: 

Richard J. Mitchell  
Reg. No. 34519